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PRELIMINARY DESIGN OF SURFACE FILTRATION UNITS (MICROSCREENING)

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This report describes a mathematical model that can be used for preliminary design of microscreening or surface filtration units. A computer program (FORTRAN 1130) describing the model is also listed and requires an input of the hydraulic, organic and solids load to calculate the solids and the organics that are removed. The program also calculates the capital and operating and maintenance costs.

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INTRODUCTION

Microscreening may be visualized as mechanical filtration (Figure 1). A fabric of metallic or plastic construction is fastened to a drum rotating about a horizontal axis. The weave of the screen, the speed of rotation, the suspended solids content and the headloss determines the effectiveness of the filtration. The influent enters the open end of the drum, passes through the screen leaving the solids embedded on the screen. As the drum revolves, the solids are carried to the top of the unit and washed off into a hopper for disposal.

Solids are deposited on the screen and also in the pores. As the solid mat builds up, it too provides additional filtration. The work of Ives[1] has shown that although both mechanisms (deposition in the pores and on the surface) occur, their overall effect can be best approximated by Boucher's straining law[2]. The relationship is

$$1) \quad H = \frac{QC_f}{A} e^{IQ/S}$$

where

H = headloss, ft.

Q = rate of flow, cu. ft./sec.

A = effective submerged filter area, sq. ft.

I = filterability index, ft^{-1}

S = speed of rotation, area per unit time entering the water, $ft^2/sec.$

C_f = assuming that the pressure drop in feet of water caused by the flow of clean water through the screen is directly proportional $H = C_f(Q/A)$ to the loading (Q/A) the factor of proportionality is C_f, $ft/((ft^3/sec)/ft^2)$

The values of the constants are sketchy. C_f data is available for the Glenfield and Kennedy Microstrainer. The values are 1.8 sec and 1.0 sec for the Mark O and Mark I filter fabrics respectively.

The filterability index is some property of the influent suspended solids. Bodien and Stenburg[3] observed this at Lebanon, Ohio and obtained the least squares regression fit below

2) $I = 0.494C$ for the Mark I

3) $I = 0.648C$ for the Mark O

Where C is the concentration of the suspended solids in mg per l. These relations 2) and 3) hold true only for Lebanon, however, it is reasonable to assume that their application may be extended to effluents from other similarly operated plants.

OPERATION AND PERFORMANCE

Boucher's law describes the relationship between operating parameters as flow, headloss, drum speed and area of filter. Bodien and Stenburg evaluated the performance characteristics. They were able to determine that the filtrability index and consequently the headloss is some function of the solids concentration at a particular removal efficiency. The average removal efficiencies they found are tabulated below:

Table 1

Removal Efficiencies for Glenfield and Kennedy Microstrainer at Lebanon, Ohio

Fabric	screen opening microns	Percent Removal			
		Suspended Solids	BOD	TOC	Turbidity
Mark I	35	73	61	30	60
Mark O	23	89	81	30	76

Diaper[4] has analyzed several installations and based on his and Bodien and Stenburg's work, the removal efficiency will vary between 55% and 90%. Actually, there has been little work done to develop a mathematical relationship which would predict efficiency. Such a mathematical relationship is proposed in Appendix A.

The influence of particle size on microstrainer efficiency has been demonstrated by Ludwig et al[5]. The relationship is simple. Below a certain particle size there is no straining and above this size, a sharp rise in efficiency occurs which remains fairly constant as the size increases.

It would be desirable to relate performance and operating parameters. The designer is interested in the amount of area required to filter a particular flow. An examination of 1) shows that the grouping (Q/A) is possible. Thus,

$$4) \quad A = \pi DLU$$

where D = diameter of drum, ft.
L = length of drum, ft.
U = fraction of drum underwater

and

$$5) \quad S = \frac{\pi DL}{T} = \frac{A}{UT}$$

Where T = time for one revolution.

Substituting 5) into 1)

$$6) \quad H = \frac{Q}{A} C_f e^{IQUT/A}$$

Equations 2) and 3) state

$$7) \quad I = K C$$

where K is the Bodien Stenburg constant. Substituting 7) and 6) yields

$$8)\quad H = \frac{QC_f}{A}\ e^{KCUTQ/A}$$

Let $Q/A = Y$ and after rearranging 8)

$$9)\quad \ln H/C_f = KCUTY + \ln Y$$

The designer is interested in the value Y. Unfortunately, Y cannot be determined from equation 9 by direct means. A numerical solution as will be described later will be used.

MODEL REPRESENTATION

The model was written to be included in the Executive Digital Computer Program[1]. Consequently, the stream vectors, listed in Table II must be compatible. The decision matrix is listed in Table III and concerns parameters pertaining to the microscreening process. The station numbers in the decision matrix refer to Figure 2.

In this mathematical model, the values of the influent stream matrixes are known. The question is what is the size of the apparatus required to accomplish a certain quality of the effluent. The quality of the effluent shall be determined by the BODOT. The remaining DMATX values determine the type of equipment and some of the operating conditions to be used. If the microscreening device can accomplish better quality effluents than required, then it would be economical to by pass some of the flow and as a result reduce the size of the device.

Figure 2 shows the complete layout of the microstrainer. Q_2 is the design flow through the microscreening device.

If a 5% waste rate is assumed then

$$Q_2' = .95*Q_2$$

and

$$Q_4 = .05*Q_2$$

TABLE II

CONTENTS OF STREAM MATRIX (SMATX)

Row No.	Descriptive Parameter	FORTRAN Variable Names
1	Stream Number	SMATX(1,I)*I
2	Volume Flow, mgd	SMATX(2,I),Q
3	Solid Organic Carbon, mg/l	SMATX(3,I),SOC
4	Solid Nonbiodegradable Carbon, mg/l	SMATX(4,I),SNBC
5	Solid Organic Nitrogen, mg/l	SMATX(5,I),SON
6	Solid Organic Phosphorus, mg/l	SMATX(6,I),SOP
7	Solid Fixed Matter, mg/l	SMATX(7,I),SFM
8	Solid BOD, mg/l	SMATX(8,I),SBOD
9	Volatile Suspended Solids, mg/l	SMATX(9,I),VSS
10	Total Suspended Solids, mg/l	SMATX(10,I),TSS
11	Dissolved Organic Carbon, mg/l	SMATX(11,I),DOC
12	Dissolved Nonbiodegradable Carbon, mg/l	SMATX(12,I),DNBC
13	Dissolved Nitrogen, mg/l	SMATX(13,I),DN
14	Dissolved Phosphorus, mg/l	SMATX(14,I),DP
15	Dissolved Fixed Matter, mg/l	SMATX(15,I),DFM
16	Alkalinity, mg/l	SMATX(16,I),ALK
17	Dissolved BOD, mg/l	SMATX(17,I),DBOD
18	Unassigned	
19	Unassigned	
20	Unassigned	

* I designates the stream number

TABLE III

CONTENTS OF DECISION MATRIX (DMATX)

FORTRAN Variable Names	Descriptive Parameter
DMATX(1,N), BODOT	Total BOD in effluent, mg/l
DMATX(2,N), REFAC	BOD removal factor = $\frac{SBOD_2'}{SBOD_2}$
DMATX(3,N)	Headloss, ft.
DMATX(4,N)	Number of drum revolutions per minute, RPM
DMATX(5,N)	Type of fabric If Glenfield and Kennedy Mark I Code = 1 Mark II Code = 2

Continuity requires that

$$Q_1 = Q_2 + Q_3$$

and

$$Q_5 = Q_1 - Q_4$$

Using descriptive terminology, $SBOD_i$ is the solid BOD at station i REFAC is the removal efficiency factor and is expressed as

$$REFAC = \frac{SBOD'_2}{SBOD_2} = 1 - \frac{SBOD_2 - SBOD'_2}{SBOD_2}$$

A mass balance around the microstrainer yields per unit time; mass flow out of microstrainer unit + mass in bypassed flow = mass flow leaving at Station 5.

$$10) \quad Q'_2 * SBOD * REFAC + Q_3 * SBOD = Q_5 * SBOD_5$$

and substituting into 9) all the above relations for Q'_2, Q_3, Q_5 yields

$$11) \quad Q_2 = \frac{Q_1 \ (SBOD - SBOD_5)}{SBOD \ (1 - 9.5 * REFAC) - .05 * SBOD_5}$$

Note that if there is no bypass flow, then the BOD in the effluent, BODOT(N) is REFAC* SBOD + DBOD,

$$12) \quad BODOT(N) = REFAC*SBOD+DBOD$$

where DBOD is the dissolved BOD influent.

It is assumed that the percent of SBOD removed is identical to the percent of suspended solids removed, PCSS. Consequently,

$$REFAC = 1 - PCSS/100$$

In the computer program the performance of a microscreening device is given by equation 11).

But

$$DESQ = Q_2 = \text{design flow}$$

and

$$BODOT = SBOD_5$$

If, however, the removal efficiency is too low to produce the required BODOT, then the computer will print an error message and also calculate the maximum BODOT obtainable from equation 12). The DESQ will be the influent flow. Appendix B is the listing of the computer program.

Now that the design flow is known, it becomes necessary to evaluate Y of equation 9) and then estimate the area of the filter. To solve equation 9) two new parameters are named.

$$TEST1 = ALOG(DMATX(3,N)*34.453/CF)$$

and

$$TEST2 = ALOG(Y1) + BK*Y1$$

where

DMATX(3,N) is the headloss in inches

$CF = C_f$

BK = .095359*BSK*SMATX(10,IS1)/DMATX(4,N)

SMATX(10,N) = the total suspended solids concentration

DMATX(4,N) = the time required for one revolution

BSK = The Bodien Stenburg constant

Y1 = Y at point 1

If Ln Y is expanded into a series

$$\ln Y = \frac{Y-1}{Y} + \frac{1}{2}\left(\frac{Y-1}{Y}\right)^2 \quad t+_____$$

and only the first term of the series is substituted for line Y in equation 9) and the equation then becomes after rearranging

$$13) \quad KCUTY^2 + (1 - \ln H/C_f)\, Y - 1 = 0$$

Using the quadratic formula Y is evaluated

14) Y1 = (TEST1 - 1. +((TEST1 - 1.)**2. + 4BK)**.5)/(2.*BK)

Y1 estimates by equation 14) is a good first guess. It was also found that positive root of the radical in 14) gave a better approximation of Y1.

The Newton-Raphson iteration is next applied. Y2 is chosen arbitarially as a point 0.5 units below Y1. TEST2 is evaluated for Y1 and TES31 = TEST2 - TEST1. Similarly, TEST2 is again evaluated for Y2 and TES32 = TEST2 - TEST1. These two points Y1 and Y2 are assumed to lie on a straight line and the slope is calculated.

SLOPE = (TES32 - TES31)/(Y2 - Y1)

TES31 is set to zero and Y1 is calculated

Y1 = Y2 - TES32/SLOPE

This gives a new value of Y1 from which a new Y2 and SLOPE are generated.

The process continues until the difference between TEST2 and TEST1 is less than .01 (less than 1% accuracy for Y1).

When Y is known (Y = Y1) the area of the filter can be calculated.

AREA + DESQ/(Y*.00144*.7)

The area was divided by .7 because the area as defined by Boucher's equation was the effective submerged area. It is assumed that in a microscreening device 70% of the total area is submerged.

COST ESTIMATES

Since most of the performance and operating data available in the literature are for Glenfield-Kennedy Microstrainers, costs were also based on their estimate. To simplify the cost estimates, all prices are based on the 10x10 unit with a quantity discount and a sliding scale excess capacity factor ECF. The ECF is expressed by the following FORTRAN relation:

ECF = 1.59*UNIT** -.082

Where

UNIT is the number of units.

The relationship is valid to 200 units. The quantity discount is given in Table IV.

Table IV

Number of Units	Cost including land, installation and accessories
1 - 2	$86,200
3 - 4	$81,200
5 or more	$76,200

The above table was inserted into the program with logic to determine the proper discount.

COMPUTED CHARACTERISTICS

The mathematical model was now used to generate design data under various conditions. In proper design of a microstrainer one must also consider the problem of concentration frequency distribution of the influent solids. A change in the influent solids concentration will effect the flow through the microstrainers. If the flow is maintained constant, then the headloss and/or drum speed must be changed. It will remain for the design engineer to make this estimate. Figure 3 was developed to aid the engineer in working this decision. Here the headloss and drum speed remain constant but the area of the surface filter required varies, demonstrating that larger suspended solid concentrations require larger filter surface areas. Additional surface areas cost more to buy and to operate as shown in Figure 4. The influence of suspended solids on total cost in cents per thousand gallons is evident.

Increasing the drum speed (headloss = 6 inches) or increasing the headloss (drum speed = 4 RPM) at constant flow and suspended solids also influences the filter surface area as can be seen from Figure 5. The variable most likely to be changed is the drum speed. Figure 6 illustrates the relationship of drum speed and total costs in cents per thousand gallons.

NOMENCLATURE

A = effective submerged filter area, sq. ft.

C = concentration of suspended solids, mg/l

C_f = clean water parameter for fabric in Boucher's law, sec.

D = diameter of drum, ft.

H = headloss, ft.

I = filterability index, ft^{-1}

K = Bodien Stenburg constant

L = length of drum

Q = rate of flow, cu. ft./sec.

S = speed of rotation, area per unit time

T = time for one revolution, sec.

U = fraction of drum underwater

Y = Q/A

FORTRAN Symbols not listed in Tables II and III

AREA = area of surface filter, sq. ft.

BK = .095329*BSK*SMATX(10,IS1)/DMATX(4,N)

BSK = Bodien Stenburg constant

CF = C_f in Boucher's law

DESQ = design flow, mgd

ECF = excess capacity factor

PCSS = per cent of suspended solids removed

SLOPE = (TES32 - TES31)/(Y2 - Y1)

TES31 = TEST2 - TEST1

TES32 = TEST2 - TEST1

TEST1 = ALOG(DMATX(3,N)*34.453/CF)

TEST2 = ALOG(Y1) + BK*Y1

UNIT = number of 10 x 10 units

Y1 = Q/A at point 1

Y2 = Q/A at point 2

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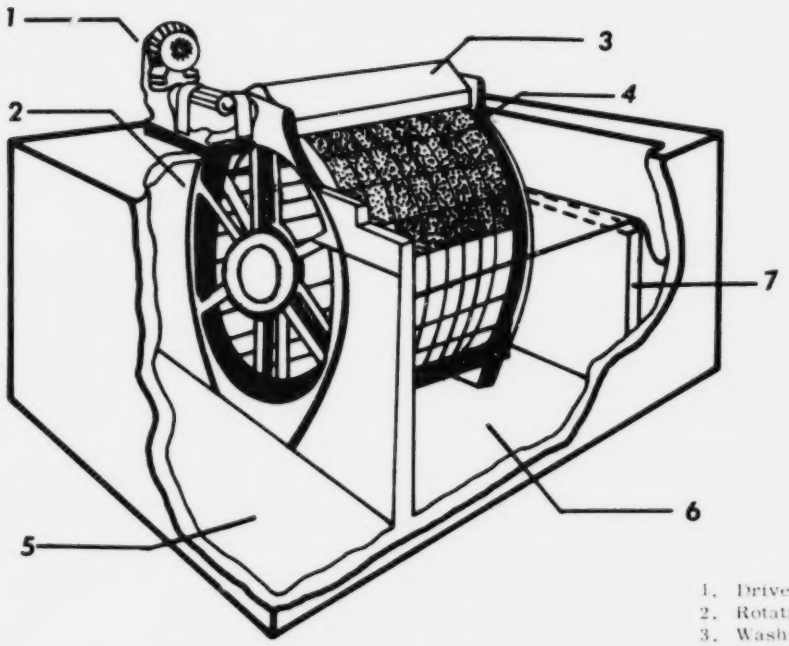

Fig. 1 Typical Microstrainer Unit

1. Drive Unit
2. Rotating Drum
3. Wash-water Jets
4. Micro-fabric
5. Influent Chamber
6. Effluent Chamber
7. Effluent Weir

Not Shown

Wastewater Hopper
Ultra-violet Lamp
Wash-water Pump

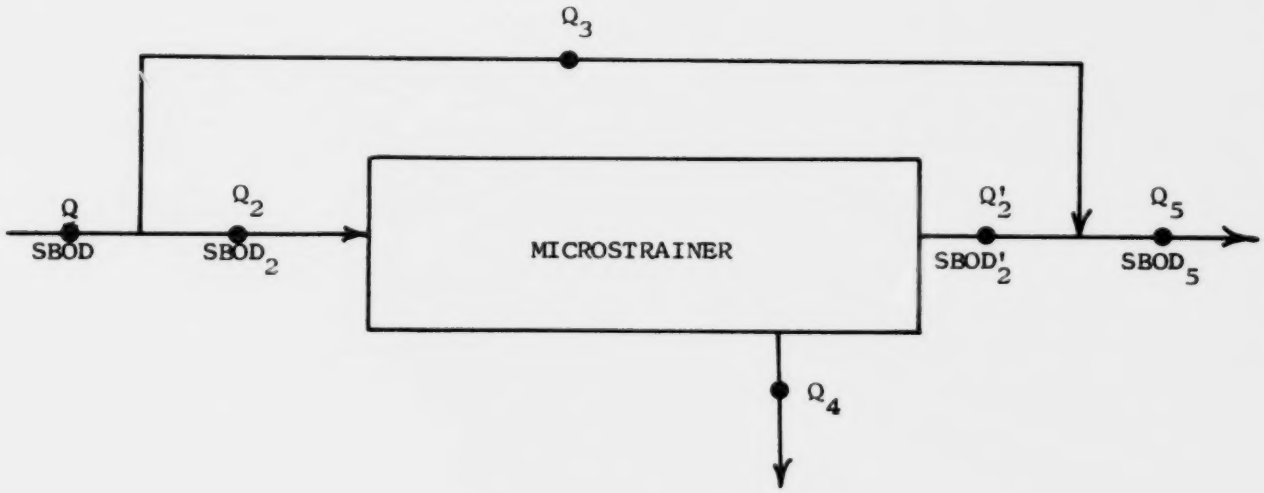

FIGURE 2

SCHEMATIC OF MICROSTRAINER MODEL

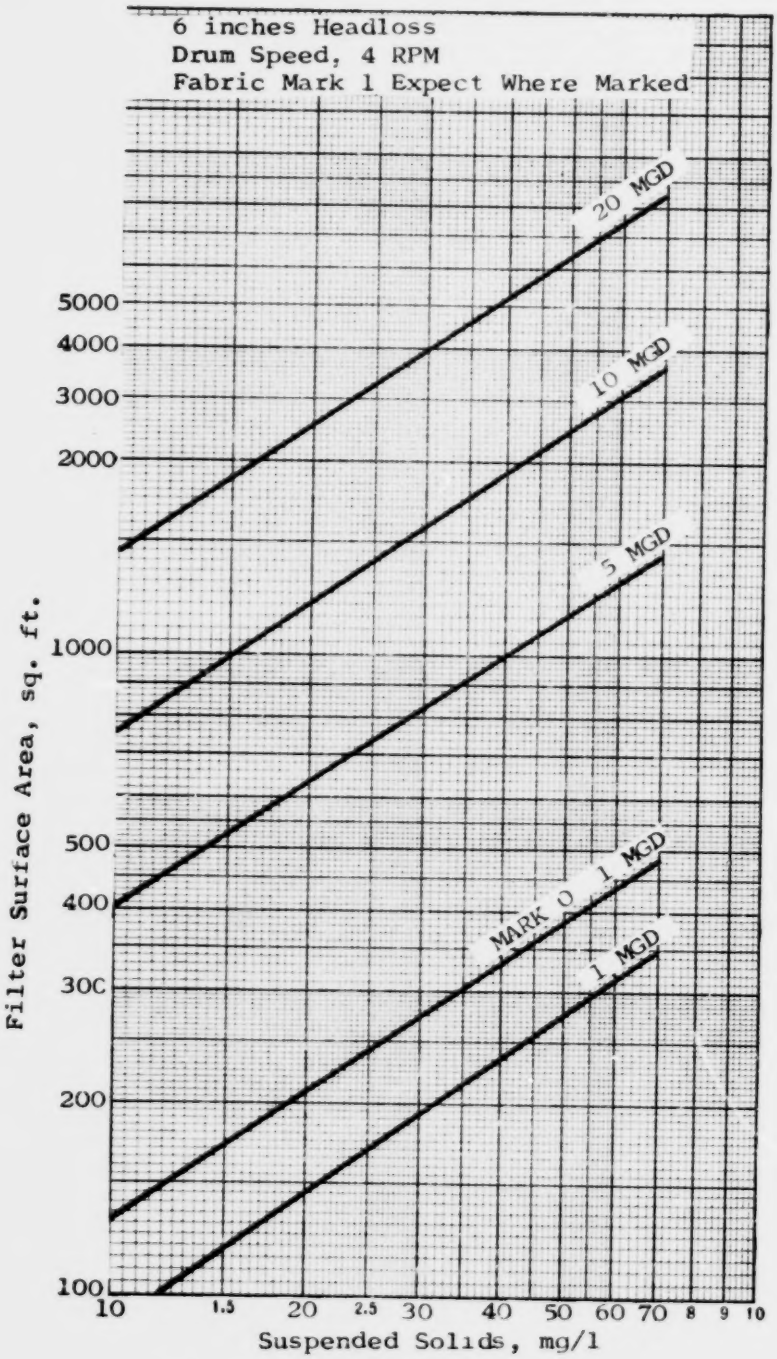

Figure 3
THE EFFECT OF SUSPENDED SOLIDS ON FILTER SURFACE AREA AT VARIOUS FLOW RATES

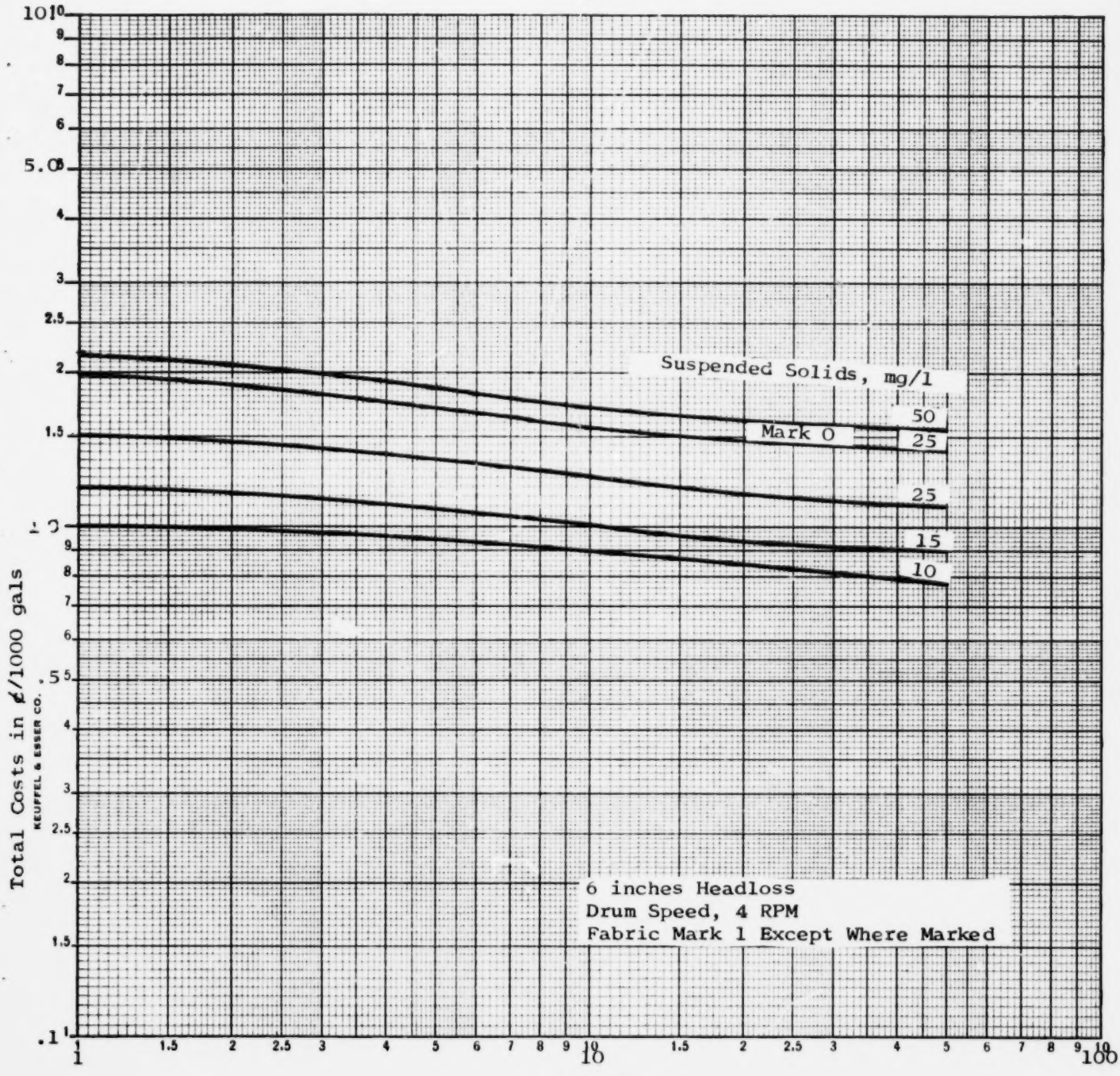

Figure 4
THE COST OF HANDLING VARIOUS SOLID CONCENTRATIONS AT DIFFERENT FLOWS

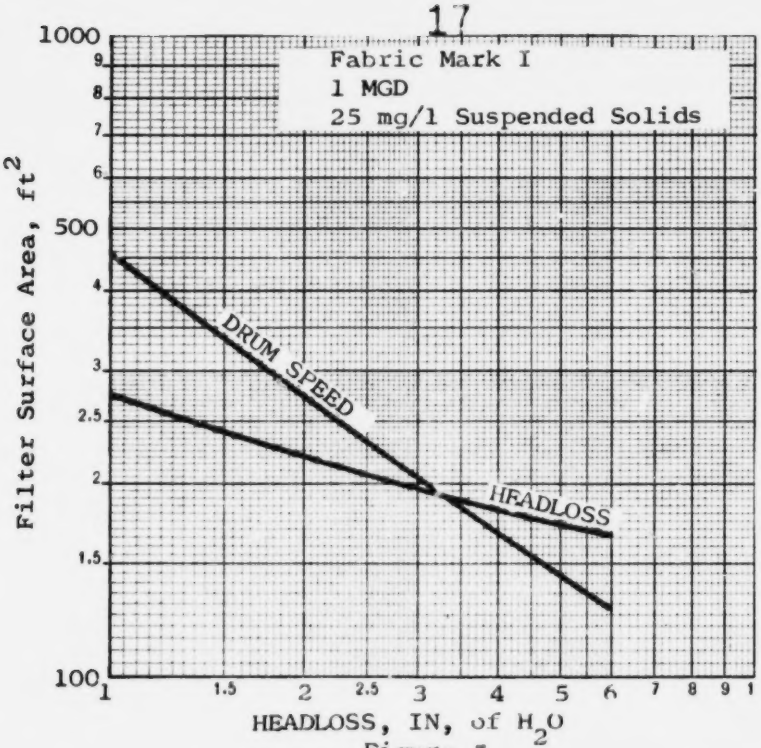

Figure 5

EFFECT OF HEADLOSS AND DRUM SPEED ON FILTER SURFACE AREA

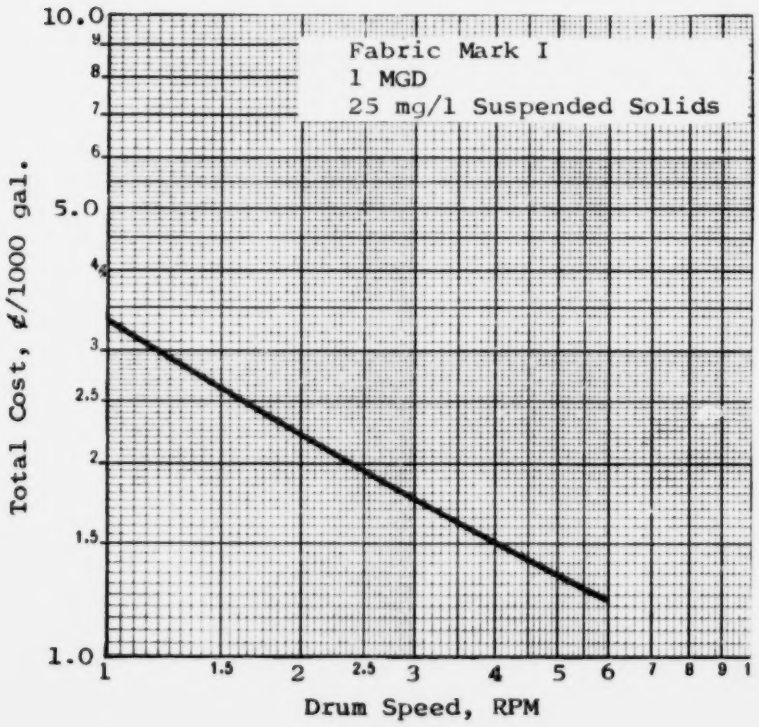

Figure 6

THE COST OF VARYING DRUM SPEED

APPENDIX A

To calculate the removal efficiency a mass balance is first set up.

Mass flow of solids out of microstrainer	+	Mass flow of solids in filtrate out of microstrainer	=	Mass flow of solids in wastewater to be strained

$$1) \qquad (1 - \varepsilon)\, L \rho_s \frac{dA}{dt} + C_o Q\rho = \frac{(Q_{pw} + \varepsilon L \frac{dA}{dt})}{(1 - C_i)} \rho_w C_i$$

where

ε = porosity of cake = $\frac{\text{volume of void space}}{\text{total volume of cake}}$

L = thickness of cake, ft

A = area of filter medium, ft^2

ρ_s = density of cake, lb/ft^3

ρ = density of filtrate, lb/ft^3

ρ_w = density of pure water, lb/ft^3

C_o = solids in effluent, lbs solids/lbs filtrate

C_i = solids in influent, lbs solids/lbs feed water

Q_{pw} = flow rate of pure water, $ft^3/min.$

Q = flow rate of filtrate, $ft^3/min.$

$\frac{dA}{dt}$ is of course the drum speed, S, in $ft^2/min.$ Several reasonable assumptions can be made to simplify 1) $\rho = \rho_w$ and second that the pure water in the cake that leaves the strainer is neglible. Thus,

$$(Q_{pw} + \varepsilon L \frac{dA}{dt}) \frac{\rho_w C_i}{(1 - C_i)} = C_i Q\rho$$

If R is defined as $(C_i - C_o)/C_i$, then a solution for S yields

$$S = \frac{Q_\rho (C_i - C_o)}{(1 - \epsilon) L\rho_s} = \frac{Q_\rho RC_i}{(1 - \epsilon) L\rho_s}$$

Note that the cake thickness, L, is subtlety defined as the thickness the instant the cake leaves the water since, referring to 1) L is defined as the mass flow of solids out of the microstrainer. As the clean fabric of the microstrainer enters the water a cake begins to build and is maximum thickness (L) on leaving the water. It would be reasonable to assume that buildup of cake is linear and that the cake is noncompressable. Therefore, L/2 is the average cake thickness. Darcy's law for flow through porous media can now be applied.

$$\frac{Q}{A} = \frac{K H_L}{(L/2) \mu}$$

where H_L is the headloss across the cake in feet and μ the viscosity. K is a constant. The headloss through the fabric must be considered also. Thus, the total headloss, H, is the sum of headloss through the cake and the fabric, H_o, but

$$H_o = \frac{Q L_f \mu}{A K}$$

where L_f is the thickness of the fabric.

Boucher also computes the headloss of the clean fabric. He evaluated H_o as

$$H_o = \frac{Q C_f}{A}$$

so therefore,

$$C_f = \frac{60 L_f \mu}{K}$$

where C_f is in units of seconds.

Therefore, the total headloss across fabric and cake is

$$H = \frac{Q\ L\ \mu}{A\ 2\ K} + \frac{C_f\ Q}{60\ A}$$

and solving for L gives

$$3) \qquad L = \frac{2\ K}{\mu} \left(\frac{AH}{Q} - \frac{C_f}{60} \right)$$

substituting 3) in 2)

$$S = \frac{Q\ \rho\ \mu\ R\ C_i}{2(1 - r)\ K\ (AH/Q - C_f/60)\rho_s}$$

Define $\frac{\rho\mu}{2K(1 - r)\rho_s} = \alpha$ and assume α is a constant

then

$$4) \qquad S = \frac{60\alpha\ Q^2\ R\ C_i}{(60A\ H - Q\ C_f)}$$

The Boucher relation is

$$H = \frac{Q\ C_f}{60\ A} e^{IQ/S}$$

or

$$H = H_o\ e^{IQ/S}$$

Solving for the filterability index I

$$5) \qquad I = \frac{S}{Q} \ln \frac{H}{H_o}$$

and substituting 4) into 5)

$$6) \qquad I = \frac{60\alpha\ Q\ R\ C_i}{(60AH - Q\ C_f)} \ln \frac{H}{H_o}$$

Regarding 6) it is evident that C_i is indeed a function of I as first observed by Bodine and Stenburg. Preliminary investigation showed that α varied from 500,000 to about 3,000,000 with an average of 1,650,000. The variation is probably caused by the failure to properly consider particle size, shape, headloss effect on filtration area, etc. Darcy's Law was used here. It is probable that more sophisticated approaches as the Carmen-Kozeny or the work of Ives would yield better results.

APPENDIX B

```
C      TEST PROGRAMS FOR MICROSTRAINER CODE NAME MICROS
C      READ SMATX,CMATX,AND CALCULATE DESIGN FLOW AND COSTS
       INTEGER CS1,CS2
       DIMENSION SMATX(20,5),CMATX(16,5),CCOST(20,5),CCSTC(20,5),
      1  BCOST(5)
     1 FORMAT(8F10.3/8F10.3/4F10.3)
     2 FORMAT(8F10.3/8F10.3)
     3 FORMAT(1X,'INFLUENT ',11F10.3)
     4 FORMAT(1X,'INFLUENT ', 5F10.3)
     5 FORMAT(1HC,16X,102HC          SCC       SNBC       SCN        SLP
      1  SFM      SBCD         VSS        TSS        DCC       DNBC)
     6 FORMAT(1HC,15X,43HDN          DP         DFM        ALK       DBCD)
     7 FORMAT(1X,'EFFLUENT ',11F10.3)
     8 FORMAT(1HC,46X,  'DESC       CCOST         CCSTC       AREA',6X,'ECF'
      1)
     9 FORMAT(43X,F8.3,2X,F11.3,2X,F11.3,2X,F8.1,2X,F8.3)
    10 FORMAT(1HO,20X,'INPUT DECISION MATRIX'/2X,'BCOST     REFAC        H
      1EADLOSS     RPM       FABRIC MARK',I2/4F10.3)
    11 FORMAT(1X,'WASTE     ',11F10.3)
    12 FORMAT(1X,'EFFLUENT ',5F10.3)
    13 FORMAT(1X,'WASTE     ',5F10.3)
    14 FORMAT(1HO,20X,'COSTS IN CENTS PER THOUSAND GALLONS'/4X,'ACEG
      1    CCEG        TCEG'/2X,3F10.3)
    15 FORMAT(1H1,40X,'MICROSTRAINER CAN NOT PRODUCE BCOST'/40X,'BEST VA
      1LUE OF BCOST IS ',F10.3)
       KK=7
       IN=2
       IC=5
       IS1=1
       OS1=2
       OS2=8
       N=1
       DO 50 K=1,KK
       READ(IN,1)(SMATX(II,1),II=1,20)
       READ(IN,2)(CMATX(I,N),I=1,16)
       REFAC=CMATX(2,N)
       Q=SMATX(2,IS1)
       DBCD=SMATX(17,IS1)
       SBCD=SMATX(8,IS1)
       BCOST(N)=CMATX(1,N)

C   CALCULATION OF MICROSTRAINER PERFORMANCE

       DESQ=Q*((SBOD-BOOST(N)+DBOD)/(SBOD*(1.0-.95*REFAC)-.05*(BOOST(N)
      1-DBOD)))
       IF(DESQ-Q) 102,101,101
  101 BOOST(N)=SBOD*REFAC+DBOD
       DESQ=Q
       WRITE(IC,15)BOOST(N)
  102 SMATX(8,OS2)=(20.-19.*REFAC)*SBOD
       RRATO=(BOOST(N)-DBOD)/SBOD
       SRATO=SMATX(8,OS2)/SBOD
       SMATX(2,OS1)=Q-.05*DESQ
       SMATX(2,OS2)=.05*DESQ
       DO 103 NI=3,10
       SMATX(NI,OS1)=RRATO*SMATX(NI,IS1)
  103 SMATX(NI,OS2)=SRATO*SMATX(NI,IS1)
```

```
      DO 104 NI=11,17
      SMATX(NI,CS1)=SMATX(NI,IS1)
  104 SMATX(NI,CS2)=SMATX(NI,IS1)
      IF(SMATX(5,N))105,105,106
  105 BSK=.684
      CF=1.8
      GO TO 107
  106 BSK=.494
      CF=1.0

C     NEWTON-RAPHSON ITERATION

  107 TEST1= ALOG(SMATX(3,N)*34.453/CF)
      BK=.09359*BSK*SMATX(10,IS1)*1./SMATX(4,N)
      Y1=(TEST1-1.+((TEST1-1.)**2.+4.*BK)**.5)/(2.*BK)
      TEST2=ALOG(Y1)+BK*Y1
      TES31=TEST2-TEST1
      Y2=Y1-.5
      TEST2=ALOG(Y2)+BK*Y2
      TES32=TEST2-TEST1
      SLOPE=(TES32-TES31)/(Y2-Y1)
  108 Y1=Y2-TES32/SLOPE
      Y2=Y1-.5
      TEST2=ALOG(Y2)+BK*Y2
      TES32=TEST2-TEST1
      TEST2=ALOG(Y1)+BK*Y1
      TES31=TEST2-TEST1
      SLOPE=(TES32-TES31)/(Y2-Y1)
      Y=Y1
      IF(ABS(TEST2-TEST1)-.01)109,109,108
  109 AREA=DESC/(Y*.00144*.7)

C     CALCULATION OF COSTS

      ECF=1.58957*(314./AREA)**.08217
      AREA=AREA*ECF
      UNIT=AREA/314.
      IF(UNIT-3.)200,201,201
  200 CCOST(N,1)=862CC.*UNIT
      GO TO 204
  201 IF (UNIT-5.)202,203,203
  202 CCOST(N,1)=812CC.*UNIT
      GO TO 204
  203 CCOST(N,1)=762CC.*UNIT
  204 COSTC(N,1)=.02*CCOST(N,1)+146C.*C
      WRITE(IC,5)
      WRITE(IC,3)(SMATX(II,1),II=2,12)
      WRITE(IC,7)(SMATX(II,2),II=2,12)
      WRITE(IC,11)(SMATX(II,8),II=2,12)
      WRITE(IC,6)
      WRITE(IC,4)(SMATX(II,1),II=13,17)
      WRITE(IC,12)(SMATX(II,2),II=13,17)
      WRITE(IC,13)(SMATX(II,8),II=13,17)
      WRITE(IC,8)
      MARK=SMATX(5,N)
      WRITE(IC,9)DESC,CCCST(N,1),CCSTC(N,1),AREA,ECF
      CCEG=CCSTC(N,1)/(SMATX(2,1)*365C.)
```

```
      ACEG=(CCOST(N,1)*.06744)/(SMATX(2,1)*365C.)
      TCEG=OCEG+ACEG
      WRITE(IC,14)ACEG,CCEG,TCEG
      WRITE(IO,1C)MARK,(DMATX(IK,N),IK=1,4)
   50 CONTINUE
      CALL EXIT
      END
```

VARIABLE ALLOCATIONS

SMATX(R)=0129-0000	DMATX(R)=0219-012C	CCOST(R)=0345-021C	CCSTC(R)=0471-0348	RCOCT(R)=0507-0474	REFAC(R)=050A
G(R)=050D	CBCC(R)=0510	SBCC(R)=0513	CESC(R)=0516	RRATC(R)=0519	SRATO(R)=051C
DSK(R)=051F	CF(R)=0522	TEST1(R)=0525	BK(R)=0528	Y1(R)=052B	TEST2(R)=052E
TES31(R)=0531	Y2(R)=0534	TES32(R)=0537	SLOPE(R)=053A	Y(R)=053D	AREA(R)=0540
ECF(R)=0543	UNIT(R)=0546	CCEG(R)=0549	ACEG(R)=054C	TCEG(R)=054F	CS1(I)=0558
CS2(I)=055C	KK(I)=055D	IN(I)=055E	IC(I)=055F	IS1(I)=0560	N(I)=0561
K(I)=0562	II(I)=0563	I(I)=0564	NI(I)=0565	MARK(I)=0566	IK(I)=0567

MICROSTRAINER CAN NOT PRODUCE BODOUT
BEST VALUE OF BODOUT IS 5.671

	Q	SCC	SNBC	SCN	SCP	SFM	SDLD	VSS	TSS	DOC	DNBC
INFLUENT	1.000	9.045	4.047	1.494	0.090	3.174	10.046	21.526	25.000	12.582	11.000
EFFLUENT	0.950	2.442	1.092	0.403	0.024	0.856	2.712	5.812	6.749	12.582	11.000
WASTE	0.050	134.499	60.178	22.215	1.338	47.197	149.384	320.091	371.750	12.582	11.000

	DN	DP	DFM	ALK	DBOD
INFLUENT	21.310	5.417	500.000	265.470	2.959
EFFLUENT	21.310	5.417	500.000	265.470	2.959
WASTE	21.310	5.417	500.000	265.470	2.959

DESG	CCOST	COSTC	AREA	ECF
1.000	46089.444	2381.788	167.8	1.752

COSTS IN CENTS PER THOUSAND GALLONS

ACEG	CCEG	TCEG
0.851	0.652	1.504

INPUT DECISION MATRIX

BODOUT	REFAC	HEADLOSS	RPM	FABRIC MARK 1
0.000	0.270	6.000	4.000	